

**DABNEY**

**A review of the  
water works plant at Kankakee**

**Municipal & Sanitary Engineering**

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**A REVIEW OF THE WATER WORKS  
PLANT AT KANKAKEE**

BY

**JOHN BLANTON DABNEY**

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**THESIS**

FOR THE

**DEGREE OF BACHELOR OF SCIENCE**

IN

**MUNICIPAL AND SANITARY ENGINEERING**

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**COLLEGE OF ENGINEERING**

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JOHN BLANTON DABNEY

ENTITLED A Review of the Water Works Plant at Kankakee

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Municipal and Sanitary

Engineering

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Instructor in Charge

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## INTRODUCTION.

Location: The water works plant at Kankakee is located on the north bank of the Kankakee River one mile southeast of the Illinois Central depot at Kankakee, Illinois. The original plant was installed in 1887 and consisted of pumps and accessories thereto for pumping the raw river water, without filtration, directly into the distributing mains. But as the area drained by the Kankakee River became more thickly populated and as towns grew up along this river and its tributaries, emptying their sewage into the streams, polluting them to a greater or less extent, the sick list in Kankakee grew larger and larger and the death rate from typhoid fever and like diseases continually increased. As the conditions grew worse and worse, it finally became necessary to employ some method of water purification.

### Installation.

The installation of the present mechanical filtration plant was begun in September 1900, at which time the population of the rapidly growing city of Kankakee was 15,000. The building which had been used for the original pumping plant was utilized as far as possible, a few additions to the building in which the filters were to be located being necessary. These changes were made and the plant was built and ready to put into operation in March 1901.

Capacity: When the filters are working at the usual rate of 125,000,000 gallons per acre per day, the gross capacity of the plant is 4,400,000 gallons per day. But since some of this



water must be used for washing the filters and coagulation basins, as well as supplying the boilers, the net capacity of the plant is about 4,000,000 gallons per 24 hours. At the present time the average daily consumption of water is 2,000,000 gallons, and as the population of the city is now (1910) 20,000, the average per capita consumption is 100 gallons per day.

#### DRAINAGE AREA.

The water is obtained from the Kankakee River, a stream having a drainage area of several thousand square miles. Part of this land is very flat and marshy and part is rolling black soil, a large percentage of which is under cultivation. Owing to the large drainage area and the level topography of the land there is not a very large variation of flow; but since the quantity of water flowing by the filtration plant at all times of the year is many times the amount required for municipal purposes, an extended discussion of this subject is deemed unnecessary.

#### CHARACTER OF WATER.

The quality of the water at Kankakee varies between wide limits, the turbidity ranging from 20 to 150 parts per million. This wide variation is due to the fact that a very large percentage of the drainage area is under cultivation and hence the soil is easily eroded and washed into the other streams. During a large part of the year the water is comparatively clear, especially during the summer and fall. In the spring the water has a high turbidity due to the thaws followed by heavy rains on the drainage area. At these times the turbidity is occasionally as high as 150 parts per million, but in general, it may be said



that as far as turbidity is concerned, the water is better than the average prairie stream.

The water of the Kankakee River has a large but not excessively high bacterial content, the number of bacteria ranging from 500 to 50,000 with an average of about 5,000 per cubic centimeter. There are a good many towns in this drainage area which empty their sewage into the Kankakee River and its tributaries, but although a sanitary survey has not yet been made of the area, it is reasonable to believe that the high bacterial content is not due entirely, but only in a small degree, to the sewage of these towns. It is very likely that most of the bacteria in the water are unharmed germs washed into the river from the neighboring fields. The following are the results of some experiments performed in 1904 by Miss Jennie Latzer, Instructor in Bacteriology at the University of Illinois, which will show that unpolluted streams sometimes have a high bacterial content.

Tests were made on water from two different lines of tile drains laid through cultivated fields, which were almost certainly free from pollution of any nature, to demonstrate how high the bacterial content may rise with no question as to pollution of the water. Samples of water were taken with great care by Mr. S. T. Henry, Jr. from the outlets of the two tile drains. The bacterial analyses were made by Miss Latzer, who used great care to make the results accurate. Duplicate platings were made on both gelatine and agar, and incubated at 22 degrees centigrade for three and five days. One of the drains is laid through



a farm just south of the city limits of Urbana, Illinois, at the end of Orchard Street, and will be called the farm tile. The other drain is laid through the southeast portion of the north farm at the University of Illinois, and through the land east of it across Lincoln Avenue, and will be called the University tile. The first samples were taken April 3, 1904, after a period of about ten days without rain. The second samples were taken April 18, 1904, about two hours after a thirty-six hour rain. The first sample from the farm tile contained 580 bacteria per cubic centimeter. The first sample from the University tile contained 590 bacteria per cubic centimeter. The sample taken from the farm tile April 18 contained 60,000 bacteria per cubic centimeter and the sample taken from the University tile at the same time contained 90,000 bacteria per cubic centimeter. As the top soil contains a much larger number of bacteria than the sub-soil, even a few inches below the surface, and as a large portion of this water must necessarily have filtered through a soil layer comparatively free from bacteria, we may reasonably expect surface waters to contain large numbers of bacteria, and still not be dangerously polluted.

#### THE PLANT.

The Water Works Plant at Kankakee consists essentially of a river intake, house intake, low lift pump, outdoor coagulation basin, indoor coagulation basins, filters, tanks for mixing the chemicals, high pressure pumps, boilers and the accessories thereto. A general plan of the plant is shown in Plate VI.



### INTAKES.

The river intake pipe is 20 inches in diameter and extends from the pump room 120 feet out into the river, which at this point is 500 feet wide. Near the end of the intake pipe there is an elbow to which a 20 inch pipe 4 feet long is attached. This short pipe points down stream at an angle of 45 degrees with the vertical. Built around it is a strainer or grating of  $3/8$  inch bars spaced one inch on centers. These bars span the end of the intake pipe and enter a hub which is attached to the end of the pipe. The elbow rests upon the bottom of the stream and by turning the short pipe up, water from near the bottom of the river and large trash is strained out by the grating. This inlet has proved very satisfactory except at times of extremely cold weather at which time anchor ice obstructs the opening and therefore it is necessary to resort to another source for water. At such times what is called the well intake is used. This well intake is 16 feet long, 8 feet wide, and 24 feet deep, the bottom being four feet below the lowest water in the river. The side of the well is parallel to the wall of the building and the well extends 8 feet under the engine room. The well is lined with brick except on the outer side where an opening 16 feet wide and 20 feet deep is left in the wall through which the water enters the well. A 20 inch intake pipe which branches from the main intake pipe and which has a grating similar to that of the river intake, extends down into this well. The gate valves on these intake pipes are so arranged that the water may be drawn from either the river or well intake by the manipulation of these



valves. No trouble is experienced with the anchor ice when the well intake is used and it has given satisfaction even during the coldest weather.

The water flows from the intake through a 20-inch pipe to the 8-inch centrifugal pump located in the northeast corner of the pump room. This pump was made by the Orange Machine Company of Lawrence, Massachusetts, and has a horizontal shaft and run<sup>is</sup> by a vertical engine. Its rated speed is 300 r.p.m. but it usually runs<sup>at</sup> 240 r.p.m. The maximim suction lift from the river at low water is 12 feet and the head against which the pump must operate is 12 feet, thus making a total head of 24 feet. When the pump is operating at the rate of 2,000,000 gallons per day, the work done by it is 278,000 foot pounds per minute or 8.5 Horse Power. It is interesting to note that this pump has been running continuously since the day of its installation in 1900, a period of 10 years, and the only repairs necessary have been an occassional packing and a new governor which has lately replaced the original.

#### OUTDOOR COAGULATION BASIN.

From the centrifugal pump the water is forced through a 16-inch pipe to within 10 feet of the distributing chamber of the outdoor coagulation basin, where the pipe increases to 20 inches in diameter and enters the distributing chamber 3 feet below the water surface at the end of the chamber. This distributing chamber is made of reinforced concrete and is 7 feet wide 26 feet long and 16 feet deep. The water flows from this chamber into the coagulation basin through holes in the masonry wall.



These holes are four inches in diameter, are in rows, and are spaced 30 inches horizontally and 12 inches vertically center to center. The top row of holes is 12 inches below the water surface and the rows extend downward to such a depth that the total area of these holes is 10 times the area of the 20-inch inflow pipe. This chamber with the holes arranged as they are is very effective in distributing the flow of water over the total cross section of the coagulation basin.

The coagulation basin is located between the coal shed and the filter room and was built of reinforced concrete. Plate III shows the type of construction. It is 16 feet deep, 26 feet wide and extends partially around the east end of the filter room, having a mean length of 86 feet. The cubical contents is 35,800 cubic feet or 268,500 gallons which is equivalent to 3.32 hours flow when the plant is working at its average rate of 2,000,000 gallons per day. Several floats were placed in this basin to determine the actual time the water remained in the basin and the average time of the several floats was one hour and 25 minutes. The actual flow could not be determined very accurately as sub-surface floats were not available. At the east end of the outdoor reservoir there is an overflow weir over which the water flows when the centrifugal pump is pumping the water into the outdoor coagulation basin faster than the filters are working. There is also a valve at the east end near the bottom of this basin through which the sediment in the basin is washed into the river. This sediment is washed out with a fire hose once in every three to eight weeks or on an average of once every



six weeks. The amount of sediment depends upon the turbidity of the water and for a period of six weeks it varies from 4 to 8 feet over the bottom of the outdoor basin.

#### INDOOR COAGULATION BASINS.

From the outdoor coagulation basin the water passes by gravity through an opening four feet wide and thirty inches deep, in the east end of the filter house into a chamber. There is a vertical slot cut in the masonry wall of this opening into which a wooden gate is fitted. By means of this gate, the opening may be entirely closed and allow the indoor coagulation basins to be operated while the outdoor basin is being cleaned. When this flow is cut off, water is supplied to the indoor reservoir by a 16 inch pipe which runs from the centrifugal pump to the east end of the filter house where it enters the above mentioned chamber.

Upon entering this chamber the water, from either the outdoor reservoir or the pipe, encounters a butterfly valve which is so adjusted as to regulate the height of the water in this chamber. In the north and south sides of this chamber there are 20-inch pipes in which there are gate valves and by means of which the water may run into either or both of the indoor basins. The water enters a compartment 11.5 feet long, seven feet wide and 16 feet deep separated from the main part of the basin by 6-inch planks set vertically and spaced 1/2 inch apart. The water flows through these 1/2-inch cracks giving a fairly uniform flow in the main part of the basin.

The main parts of these indoor coagulation basins are



34 feet long 16 feet 8 inches wide and 16 feet deep. At the west end the water flows over a <sup>weir</sup> extending entirely across the reservoir into a basin 8 feet 6 inches x 16 feet 8 inches x 16 feet deep. The total combined capacity of the indoor coagulation basins is 198,000 gallons, or 1 1/4 hours flow. Several floats were placed in these basins also and the average time for them to pass through the basin was 35 minutes thus making the total period of subsidence of the indoor and outdoor basins combined about two hours.

These indoor basins are cleaned every three months by a stream of water from a fire hose. The sediment that accumulates during this time averages about two feet in depth.

It is interesting to note that when the water was first allowed to run into the indoor reservoirs, the south wall of the basin closest to the river gave way and the entire southeast wall of the filter house was thrown into the river. This wall was rebuilt with an outer courses of brick and an inner lining of concrete. Another precaution was taken in that they put steel tie rods through this wall which extend through the indoor basins and are anchored in the opposite wall of the filter house. These rods are placed in rows 4, 8, and 12 feet above the bottom of the basin, and spaced 8 feet on centers. The bottom rods are 2, the next are 1 1/2 and the upper rods are 7/8 inches in diameter. Since the wall was rebuilt no signs of distress or failure of the wall have been noticed.

After the water flows over the long weir at the west end of the main coagulation basin into a smaller basin, it then flows over a weir six feet wide into a channel located beneath the walk



in the filter house. While flowing over the weir hypochlorite of lime is introduced into the water by a method hereinafter described.

#### FILTERS.

From the masonry channel the water flows to the filter tanks having a maximum available head at the inlet to the filters of 6 feet over the strainer system. There are eight filter tanks four on each side of <sup>the</sup> coagulated water channel under the walk which runs longitudinally through the center of the filter room. The general arrangement of the tanks is shown in Plate IV, the picture being taken from the northwest corner of the filter room. The walls and floors of the tanks were built of 1:2 1/2:5 Portland cement broken stone concrete laid wet enough so that water flushed to the surface with slight tamping. The walls are 18 inches thick at the top. On top of the walls between filters there are 1/4 inch vertical wrought iron plates so arranged as to form a trough 16 inches wide and 9 inches deep, over the <sup>of</sup> sides <sub>^</sub> and into which the dirty wash water flows. A good view of one of these troughs is shown in the foreground in Plate IV. These troughs are connected to the waste sewer which empties dirty water into the river.

The inlet to each tank is made at the middle of the side adjacent to the walk through an 8 inch pipe which branches from the coagulated water distributing channel. A butterfly valve, automatically operated by a float which may be set in such a manner as to keep the water at the desired level in the tank, controls the inflow when the filter is in operation. There is



no gate valve on the inlet pipe by means of which the flow may be cut off entirely, but the butterfly <sup>valve</sup> serves the purpose when the filter ~~is~~ being washed. The two filters at the west end of the room are equipped with an iron trough 12 inches wide and 24 inches long, the top of which is one inch <sup>below</sup> the water surface in the filter. The water flows from the inlet pipe into one end of this trough and out over the edges, thus giving fairly good distribution of flow. In the other six filters a wrought iron basket 2 feet in diameter is attached to each of the inlet pipes and the water flows over the edge as well as out through the slots in the side of the basket. The distribution in this case is slightly better than that of the arrangement of the above described controller

At the bottom of the filter bed is a 6 inch layer of crushed stone about 1/2 inch in diameter, over which are 2 inches of carefully graded crushed stone, upon which lies 4 feet of sand. This sand has, when clean, an effective size of .60 millimeters, a uniformity coefficient of 1.23 and a porosity of 35 percent. The analysis of the sand was made with great care by the writer and includes the percentage of voids, uniformity coefficient, and effective size. The result of the analysis are shown on Plate VII. The depth of water above the sand is from 16 to 18 inches.

The strainer system comprises a brass manifold placed lengthwise of the tank at the center, 8 inches in diameter at the outlet end and decreased by steps to 4 inches at the outer end. To this manifold are attached sixteen 1-inch brass laterals on each side, extending at right angles to the manifold.



At intervals of 12 inches along these laterals are placed the strainers, 460 in number for each filter. They are made of brass, having a flat round top and slots in the sides through which the water enters.

Air is supplied for washing by 2-inch pipes laid parallel to the manifold but adjacent to each of the side walls. Branching from each of these 2-inch pipes are thirty-two  $1\frac{1}{2}$  inch brass pipes laid at right angles to the mains and overlapping one foot at the center. In the sides of these laterals are  $1\frac{1}{16}$  inch holes spaced four inches center to center on alternate sides of the pipe. The 2-inch mains pass up through the sand at the corner of the filters and are connected above the walk to a four-inch main leading from the air compressor in the pump room. These pipes may be seen in Plate IV.

The filter tanks are washed separately by forcing a reverse current of water through the strainer system and at the same time agitating the sand beds with jets of air under a pressure of 5 pounds per square inch. The air is supplied by a 12 x 3 air compressor made by the Deane Steam Pump Company of Holyoke, Massachusetts, which was installed in 1901, and which delivers air at a pressure of fifteen (15) pounds per square inch. It is located in the pump room as shown in Plate VI. The water is supplied from the service mains having a pressure of 60 pounds per square inch, but in passing through the small pipe and out of the strainer system the loss of head is very great and it was observed on a compound gage by the writer that the pressure in the gravel during times of washing ranged between 4 and 6 pounds per square inch. The wash water pipe is connected to the



filtered water pipe just outside of filter wall and valves are placed on both pipes so that it is possible to shut the valve in the effluent pipe, open the wash water valve and thus reverse the flow in the filter bed.

There is a compound gage on the operating floor which is connected to a pipe that is open at the bottom of the filter bed. This gage registers zero when the filters are clean, and while the process of washing is going on it registers the pressure at the bottom of the bed. As dirt accumulates on the filter bed, the gage registers a vacuum of more or less intensity according to the amount of accumulation on the filter bed. When the bed is so cloggrd that no water will flow through, the gage registers five inches of mercury. However, this condition is seldom if ever reached for it is the instruction <sup>to</sup> the operator to wash the filters when the vacuum is four inches of Mercury. The interval between washings varies according to the turbidity of the water from once to four or five times in 24 hours. When the filters are washed, the water is forced up through the sand, thence over into the trough between the filter tanks, from which it flows by gravity into the waste sewer and thence into the river. Plate II shows the waste sewer 10 inches in diameter, coming down out of the filter house. The process of washing is as follows: cut off the filter from the clear water reservoir; turn on wash water from city mains; turn on air; let both run for 15 minutes; turn off air; let city pressure run three minutes longer; cut off city pressure; rinse filters for five minutes by allowing effluent to discharge through sewer into river; turn effluent into



clear water reservoir. The total time required for washing is from 20 to 25 minutes, and when the interval between washings is the shortest, the water used for washing does not average more than 5 % of the amount filtered.

As above stated, the total capacity of the filters when operating at a rate of 125,000,000 gallons per acre per day is 4,400,000 gallons in 24 hours. But since time is lost in washing and water is used for washing the filters and coagulation basin and supplying the boilers, the actual rated capacity of the plant is 4,000,000 gallons per day. Since there are eight filters, the rated capacity of each is 500,000 gallons per day, which is 20,800 gallons an hour or 348 gallons per minute. The filters are 12 feet wide by 16 feet long and have an area of 192 square feet. This area holds 1440 gallons per foot or 120 gallons per inch <sup>in</sup> depth. In order to operate at a rate of 340 gallons per minute, the water must drop 2.84 inches per minute in the upper portion of the tank. As the sand in the bed has only 35 percentage of voids, it is seen that the drop in the sand is much more rapid than 2.84 inches per minute.

The operation of the filters is entirely from the walks along the center of the filter room. The valve stems extend up above the floor for convenience in the operation of the filter tanks. These valve stems may be seen in Plate IV. The discharge from the filter was originally controlled by automatic controllers but as the results were considered unsatisfactory by the superintendent and on account of the additional work necessary to keep them in order they were discarded. The effluent is



now controlled by opening the valve on the effluent pipe one and a half turns of the valve stem. This opening remains the same from one washing to the other. It is evident that under the head of six feet, which exists when the filters are clean, the discharge through the opening is greater than when the head has been decreased by the accumulation of dirt on the surface of the bed. This excessive or increased flow comes at a time when the sand is clean and the no scum or veil has been formed over the sand bed, at which time possibility of large numbers of bacteria flowing through the sand bed is much greater than when the bed is slightly dirty. Although the above method of effluent control does not theoretically fulfill the requirement, it has proven more satisfactory to the superintendent than that by automatic controllers.

There is a graduated board which has a pointer attached to the upper end of a rod, the lower end being connected to a float in the clear water reservoir, to show the depth of water in the reservoir.

#### CLEAR WATER RESERVOIR.

From the filters, the water flows by gravity into the clear water reservoir. Each filter is connected directly to the reservoir by an eight inch pipe, which has an inverted gooseneck near the outlet end. The water from the two filters in the west end of the filter room discharges over the edges of their respective pipes which form the goosenecks, while each pipe from the other six filters enters<sup>s</sup> the bottom of a wrought iron receptacle 4 feet in diameter and 3 feet deep. These are



supported by I-beams which span from wall to wall. The water fills them, and flows over the sides into the reservoir. In passing over the edges in thin sheets, the water is more or less aerated. These receptacles perform another duty in that they catch any sand that may pass through the strainers down into the reservoir. They were the original effluent controllers, but after another method of controlling the discharge was adopted, they were dismantled and now serve the above described purpose.

The clear water reservoir is located under the filter room and is 75 feet long, extending 23 feet beyond the west end of the filter room as is shown in Plate II. The reservoir was built entirely of concrete. It consists of three parallel compartments running longitudinally with the filter house. Each compartment is 75 feet long, 12 feet 6 inches wide, and 10 feet 6 inches to the springing line of the arched cover. Each of the outer compartments are connected to the central one by 3 holes, 3 x 3 feet placed near the bottom of the partition wall. These holes allow a free circulation of the water in the several compartments of the reservoir. Each of these compartments has a capacity to the springing line of the arch of 985 cubic feet or 7400 gallons making the total capacity 22,200 gallons. This is equivalent to about two hours supply when pumping at a rate of 2,000,000 gallons per day.

#### PUMPS.

From the clear water reservoir the water is lifted through a 16 inch suction pipe to the pump which forces it into the distributing mains. These mains are connected to a stand pipe



located in the northern part of the city, the average pressure being sixty pounds per square inch. The pump used for this purpose is a Laidlaw-Dunn-Gordon Corliss Pumping Engine which was installed in 1909. It was manufactured and furnished by the Laidlaw-Dunn-Gordon Company of Cincinnati, Ohio. Plate V shows a general view of the engine as it now stands. It is of the cross compound, condensing, crank and fly wheel type. The principal dimensions are as follows:

High pressure cylinder	14 inches.
Low pressure cylinder	28 inches.
Water plunger	11 1/4 inches.
Steam piston rod	2 15/16 inches.
Water plunger rod	2 5/16 inches.
Stroke	24 inches.

This engine was purchased under a guarantee that the duty would be 106,000,000 foot pounds per 1000 pounds of dry steam and that it should discharge 3,000,000 gallons per day. A test was run on the engine while it was delivering water at a rate of 2,850,000 gallons per day. This test, although run at about 5 percent under the rated capacity of the engine, showed a duty of 114,800,000 foot pounds per 1,000 pounds of dry steam supplied. It was demonstrated preliminary to the test, that the engine is capable of delivering in excess of its rated capacity, and the fact that the delivery during the test was slightly less than the capacity indicates nothing further than that the duty would have been a trifle greater had the engine been speeded by one or two revolutions, and thus equal or exceeded its rating. At fifty-five



revolutions per minute the pump would discharge 3,168,000 gallons per day.

Besides the previously mentioned centrifugal pump, air compressor, and corliss engine, several other pumps, shown in Plate VI, will now be described.

The vacuum pump used in connection with the Corliss engine, was manufactured and furnished by the Blake and Knowles Manufacturing Company, of Boston, Massachusetts. It was installed in 1909. The size of this pump is 6 x 9 x 10 and the vacuum which it produces ranges from 25 to 27 inches of mercury.

There are two Gordon-Maxwell Pumping engines of the tandem compound, outside, center packed, type located near the center of the pump room, as shown in Plate VI, each having a capacity of 1,000,000 gallons per day. These were installed in 1887 and were used during subsequent years for pumping the raw water, without filtration, into the distributing mains. They are now seldom operated, serving only as an auxiliary to supplement the centrifugal pump when it is being repaired or cleaned.

On the north side of the pump room there is a tandem compound duplex, inside center packed pumping engine manufactured by the Deane Steam Pump Company of Holyoke, Massachusetts. The size of this engine is 12 by 24 by 16 by 18, and it has a capacity of 3,000,000 gallons per day. This pump was installed in 1901 and was used, before the installation of the Corliss Pumping Engine, for pumping the filtered water into the distributing mains. It is now used as an auxiliary or reserved in case of a break down in the corliss engine. This Deane engine is equipped with an 8 x 18 x 12 Deane jet condenser.



It was installed in 1901 and is located between the above mentioned Gordon-Maxwell engines.

#### BOILERS.

The boilers are located in a room adjacent to the pump room as shown in Plate VI. There are three return tubular boilers in this room, two of which were furnished by the Tobin and Hamler Manufacturing Company of Chicago, Illinois, and the other by the Erie City Iron Works of Erie, Pennsylvania. The two former were installed in 1900 while the latter was put in <sup>in</sup> 1903. Each of these boilers has a capacity of 100 Horse Power and they furnish steam to the pump at a pressure of 100 pounds per square inch. Only two of these boilers are operated at a time, the third being held in reserve.

In the north west corner of the boiler room there is an 8 x 5 x 10 boiler feed pump purchased from the George S. Blake Manufacturing Company of New York City.

The coal used in heating the boilers is stored in the coal shed, which is shown in Plate VI. The amount of coal used per day is usually from six to six and one half tons. This is transported from the coal shed in a steel car which runs on a narrow gage track. Each car load of coal is weighed as it is brought to the boiler room, on the track scales in the northeast corner of the room, and an accurate account is kept of the amount of the coal consumed.

#### CHEMICALS.

The plant was designed to use iron sulphate and commercial lime as the chemicals for coagulation. These chemicals



were used from the date of installation of the plant until August 16, 1909 when they were supplanted by sulphate of aluminum and hypochlorite of lime. Experiments made with the latter chemicals proved that they were better adapted to this particular water and hence they are now used. When the turbidity of the water is very high, commercial lime is also used in connection with aluminum sulphate and hypochlorite of lime, as will be explained later.

The chemicals are stored in a room between the filter and the boiler room as shown in Plate VI., and are made into solutions on platforms in the storage room. The aluminum sulphate is, in mixed, in a tank seven feet in diameter and six feet deep located on a platform in the northwest corner of the room. In the top of this tank which is made of wood with steel hoops, there is a partition across the center and extending to a depth of 2 feet, on one side of which partition there is an impervious bottom extending over to the walls of the tank, thus forming an inner receptacle or mixing chamber. In the bottom of this chamber there is a one and one fourth inch lead pipe having  $1/8$  inch holes spaced 3 inches center to center, through which the water is sprayed upon the chemical. Adjacent to this pipe there is a  $3/4$  inch lead pipe having  $1/16$  inch holes spaced 2 inches on centers, through which steam is supplied to the mixing chamber. The aluminum sulphate is dumped into this chamber every thirty minutes in quantities ranging from 5 to 30 pounds, according to the turbidity of the water. The water flows constantly upon this chemical, and the steam agitates and raises the temperature



of the water, thus increasing its solvent power. At intervals between the introduction of the chemical, the mass is agitated occasionally by the attendant. The height of the solution in this tank is kept constant by means of a float valve attached to the inlet water pipe.

This solution of sulphate of aluminum is drawn off near the bottom of the above mentioned tank. It flows by gravity through a one and one fourth inch pipe to the intake pipe where it is introduced into the raw water before it reaches the centrifugal pump. When the water passes through the centrifugal pump the solution of aluminum sulphate is thoroughly mixed with the raw water.

The amount of aluminum sulphate used varies according to the turbidity of the water. For turbidities less than thirty parts per million, none of this chemical is used. Since there was no available scale or table showing the amount of aluminum sulphate used for different turbidities, the writer selected a number of representative figures from records, from which a curve was plotted and the following values as shown in Table I, were ascertained.



TABLE I.

The amount of aluminum Sulphate used for Different  
Turbidities of Raw Water.

Turbidity of water in parts per million	Alluminum Sulphate in pounds per 24 hours	Alluminum Sulphate in pounds per 30 minutes.
30	240	5.00
35	260	5.42
40	280	5.84
45	300	6.25
50	320	6.67
55	345	7.20
60	370	7.70
65	395	8.22
70	420	8.75
75	450	9.38
80	490	10.20
85	540	11.25
90	590	12.30
95	640	13.30
100	700	14.60



The hypochlorite of lime is mixed in the southeast corner of the chemical storage room over one end of the distributing chamber of the outdoor coagulation basin. The mixing is done in a wooden box 3 feet wide, 4 feet long and 2 feet deep, having a partition across the center. This partition is made of sheet lead for the first six inches down from the top. This sheet is perforated with holes  $1/4$  inch in diameter spaced 3 inches on centers. The lower portion of the partition is made of wood fixed rigidly to the sides of the box. In one end of the box there is a 1-inch pipe having  $1/8$  inch holes spaced 2 inches on centers through which the water flows into the box. The water is maintained at a constant level by means of a float valve attached to the inlet pipe.

Into the same end of the box one half pound of hypochlorite of lime is dumped every thirty minutes or at a rate of 24 pounds a day. The water dissolves the hypochlorite and then the solution, which has a consistency of milk, flows through the holes in the lead partition into the opposite side of the box. From here the solution flows by gravity through a 1-inch lead pipe to the weir where the water from the indoor subsidence basins flows into the channel beneath the walk in the filter room. On these weirs, which are six feet wide, there are  $3/4$  inch pipes having  $1/8$  inch holes spaced six inches on centers, through which the solution of hypochlorite of lime flows. This solution mixes with the water from the subsidence basins and flows to the filters.

The Superintendent of the plant ran a series of tests with



hypochlorite of lime in order to ascertain the proper amount to use for this particular water. Various amounts were put into the water, but experience showed that small amounts failed to fulfill their purpose of killing the bacteria, while excessively large amounts produce a slightly disagreeable taste in the water. The conclusions arrived at by the superintendent was that one half pound of hypochlorite of lime should be put into the mixing box every thirty minutes or at a rate of 24 pounds per day. No variation in the amount of this chemical is made for different conditions of the water.

When the river water is very turbid and consequently large amounts of sulphate of aluminum must be added, the quantity of this chemical is more than is required to combine with the alkalinity of the water. Since a large amount of flocculent matter is necessary when the water is in this condition, lime must be added to the raw water in order to produce this additional flock. This commercial lime is made into solution in a wooden tank situated over one end of the distributing chamber of the outdoor coagulation basin. This tank is not so tall but in other respects it is similar to that used for mixing the aluminum sulphate. The mixing is done by the same method as described above for the aluminum sulphate except that no steam is used in this case.



The sulphate of aluminum is added to the water to form an inorganic precipitate, the presence of which has a physical action upon the suspended matters, and allow<sup>s</sup> them to be more readily removed by subsidence or filtration. When this chemical is added to the water it is decomposed into its component parts, sulphuric acid and alumina. the former combines with the lime or other bases present in the water, or in case not enough of this is present it remains partly as free acid and partly undecomposed in its original condition; while the alumina forms a gelatinous precipitate which draws together and surrounds the suspended matter in the water, including the bacteria and allows them to be much more easily removed by filtration than would otherwise be the case. In addition, the alumina has a chemical attraction for dissolved organic matters, and the chemical purification may be more complete at very high rates than would be possible with sand filtration without coagulants at any rate, however low.

The bacterial efficiency of the plant is determined by experiments or tests made by the superintendent. These tests are made by the standard method of water analysis, using nutrient gelatine as a culture medium. Definite amounts of the water to be tested are placed in petri dishes with culture media, and incubated from two to four days, at a temperature of 22 degrees Centigrade. At the end of this period the colonies are counted and the results recorded for future reference. The samples, from which these tests are made, are taken from pipes near the west end of the filter room which may be seen in Plate IV. There are six of these 1/2 inch pipes which are connected to 1/2 inch centrifugal pumps located in the clear water reservoir and thence to the effluent pipes of



the respective filters. These six centrifugal pumps are run by a one inch water motor which is connected to the city main which has a pressure of 60 pounds per square inch. By means of these small pumps, samples are obtained directly from the effluent pipes without the inconvenience of going down into the clear water reservoir.

The tests for alkalinity, which are made for both raw and filtered water, are made by adding methyl orange, as an indicator, to the sample and then titrating with fiftieth normal solution of sulphuric acid. Each one-tenth cubic centimeter of sulphuric acid necessary to neutralize the alkalinity of the water equals one part per million of alkalinity as calcium carbonate.

Table II gives the results of some tests made on the water by the superintendent of the plant and were taken from the records. Tests number 1, 2, and 3 give the maximum, minimum, and average results, respectively, for the month of July 1909. At this time no hypochlorite of lime was being used, the use of this chemical beginning August 16, 1909. Numbers 4 and 5 give the maximum<sup>and</sup> minimum and number 6 gives the average results for November, 1909, exclusive of the test made on the ninth of that month. Number 7 shows the results for November 9, 1909. On that day no hypochlorite of lime was used, but on all other days during that month this chemical was put into the water at a rate of 48 pounds per day. The contrast of the decreased efficiency of the filters for that day is quite marked, thus showing the effect of hyperchlorite of lime upon the efficiency of the plant. Numbers 8, 9, <sup>and</sup> 10 show the maximum, minimum, and average number of bacteria in the raw water and



the corresponding results for January, 1910, while Numbers 11, 12, and 13 give the same results for February, 1910. During these last two months twenty-four pounds of hypochlorite of lime were used per day. Judging from these results, the use of hypochlorite of lime is very essential to the efficient operation of a mechanical filtration plant.

It may be noted that this plant has no preliminary settling basin. Such a reservoir would serve two purposes, viz, sedimentation and storage. Although storage is a thing of minor importance in this case, sedimentation is probably worthy of consideration. If there were a reservoir, having a capacity of 24 hours supply, connected with the plant, the turbidity of the water drawn from this reservoir would be 35 or 40 percent less than that of the river water. This reduced turbidity would reduce the required amount of chemical and hence the cost of operation. It is not probable that such a reservoir would raise the bacterial efficiency of the plant but from an economical standpoint it is a thing worthy of consideration.

Reviewing the plant as a whole, it is giving most admirable results as far as the analyses can ascertain. It may be said further that the most conclusive test and proof of its efficiency is the healthfulness of the people who drink the filtered water. The results which have been obtained in the efficiency of the plant and of the healthful condition of the Kankakee citizens are due to a very large degree to the admirable manner in which the plant is operated.

The writer is indebted to those who are connected with



the plant, especially to Mr. Charles H. Cobb, the superintendent, and to Mr. W. H. Reed, the chief-engineer, for the freedom granted him to work around the plant and for the valuable advice, suggestions, and questions pertaining to the plant.



TABLE II.

Number	Bacteria per		Analysis of Water.		Reduction Filters	Turbi- ity	Alkalinity	
	Raw Water	Subsi- dence basin	C.C. Filtered Water	Percentage Sedimenta- tion Basin			Raw	Filter- ed Water
1	1930	830	57.0	57.0	97.0	50	145	140
2	590	390	44	33.8	92.5	45	172	170
3	1250	450	63	64.0	95.0	60	195	190
4	47400	23400	4	50.6	99.9	80	172	165
5	2800	1800	0	35.7	100.0	30	184	181
6	19700	10600	16	46.1	99.9	50	175	165
7	12600	9560	1376	24.0	89.1	80	139	131
8	5320	2210	6	58.5	99.9	50	219	190
9	1400	502	8	64.2	99.4	110	183	161
10	3200	1500	6	53.2	99.8	65	215	208
11	11000	5020	9	54.4	99.2	95	187	178
12	650	110	2	83.0	99.6	70	207	200
13	2570	1090	12	57.5	99.5	106	200	177





VIEW LOOKING SOUTH EAST





VIEW LOOKING EAST





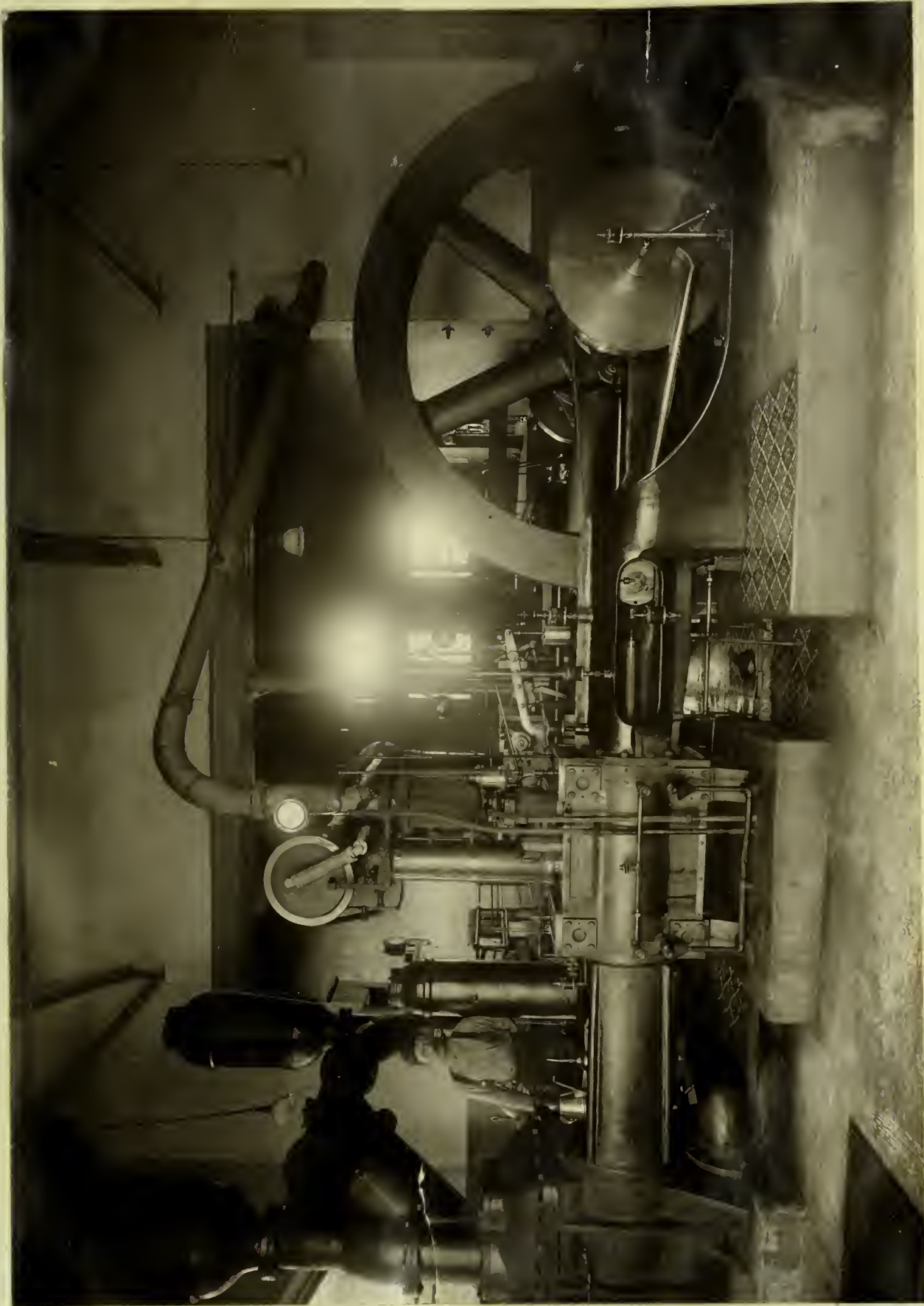
VIEW LOOKING WEST SHOWING OUTDOOR COAGULATION BASIN



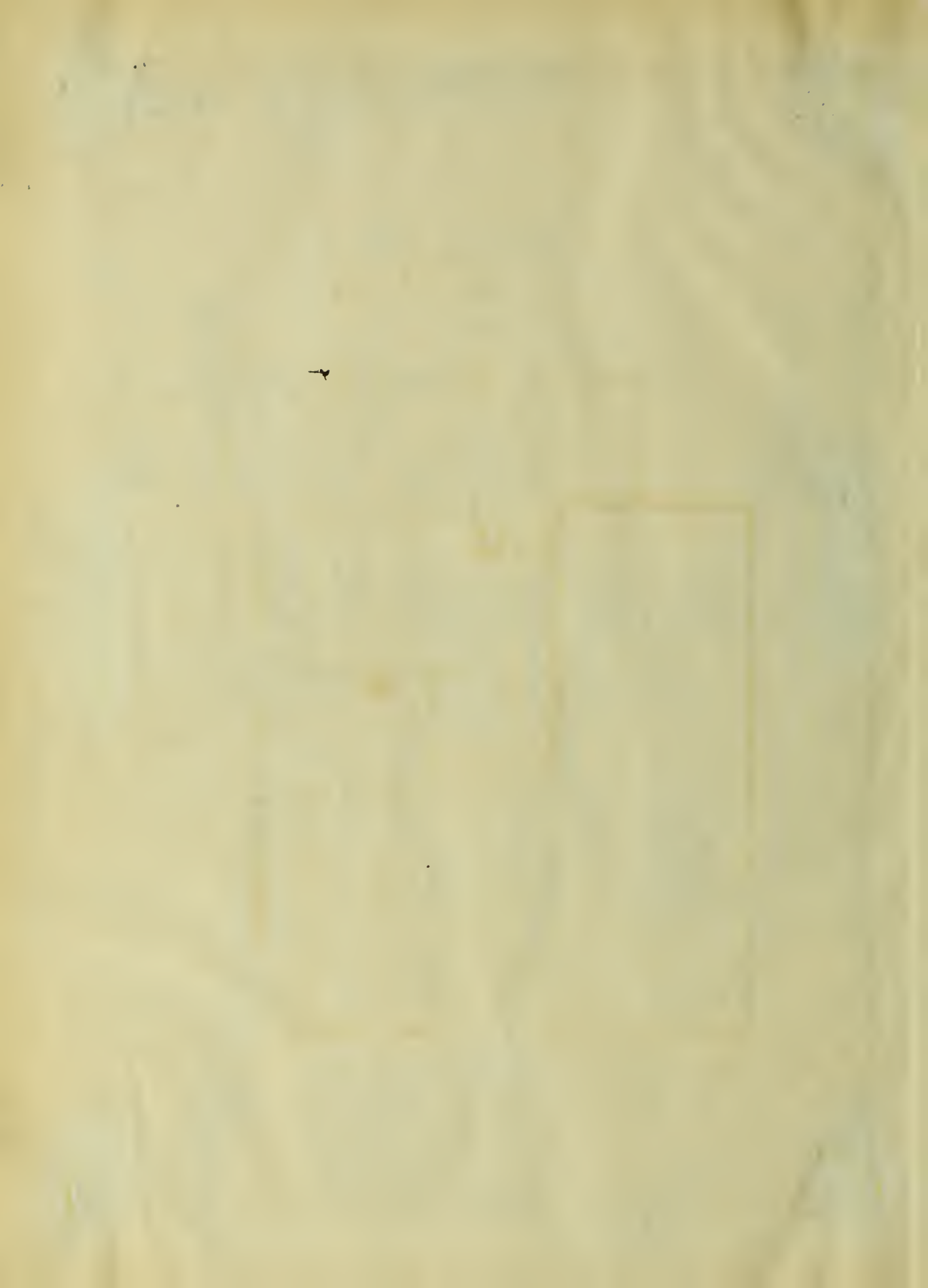


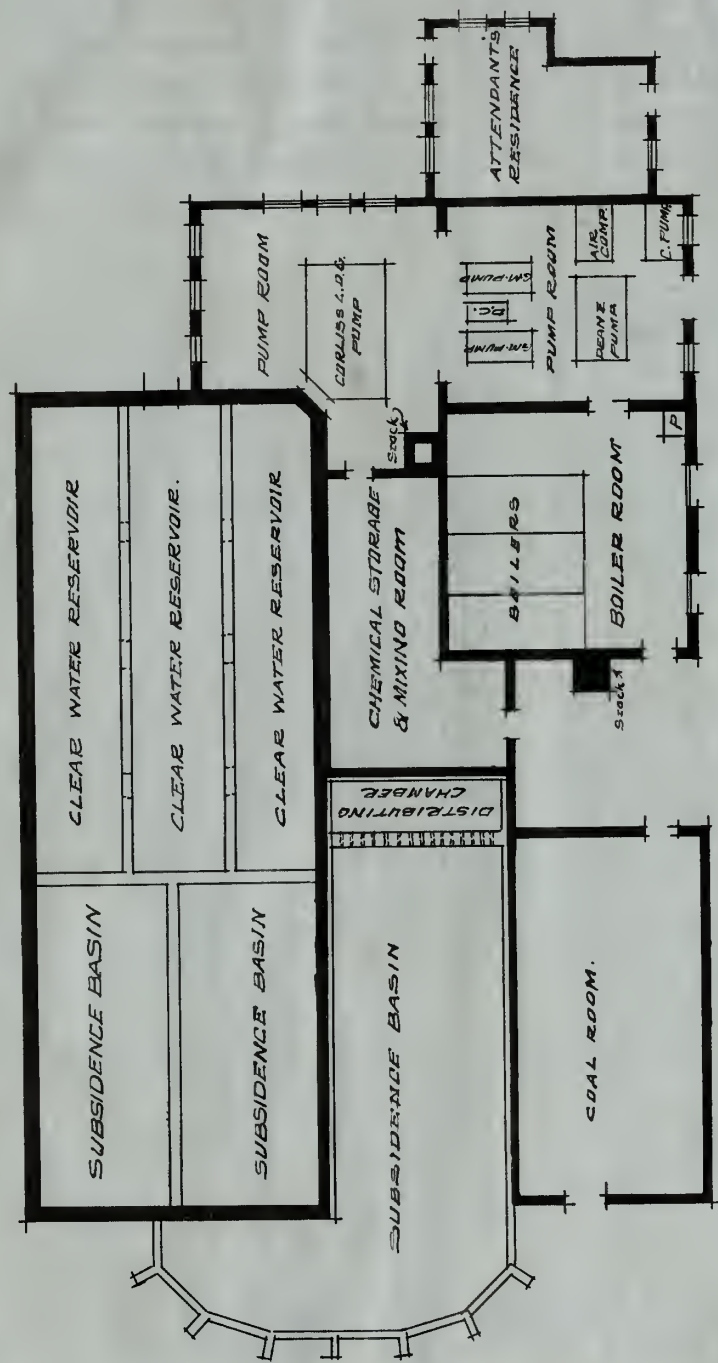
INTERIA VIEW OF FILTER ROOM





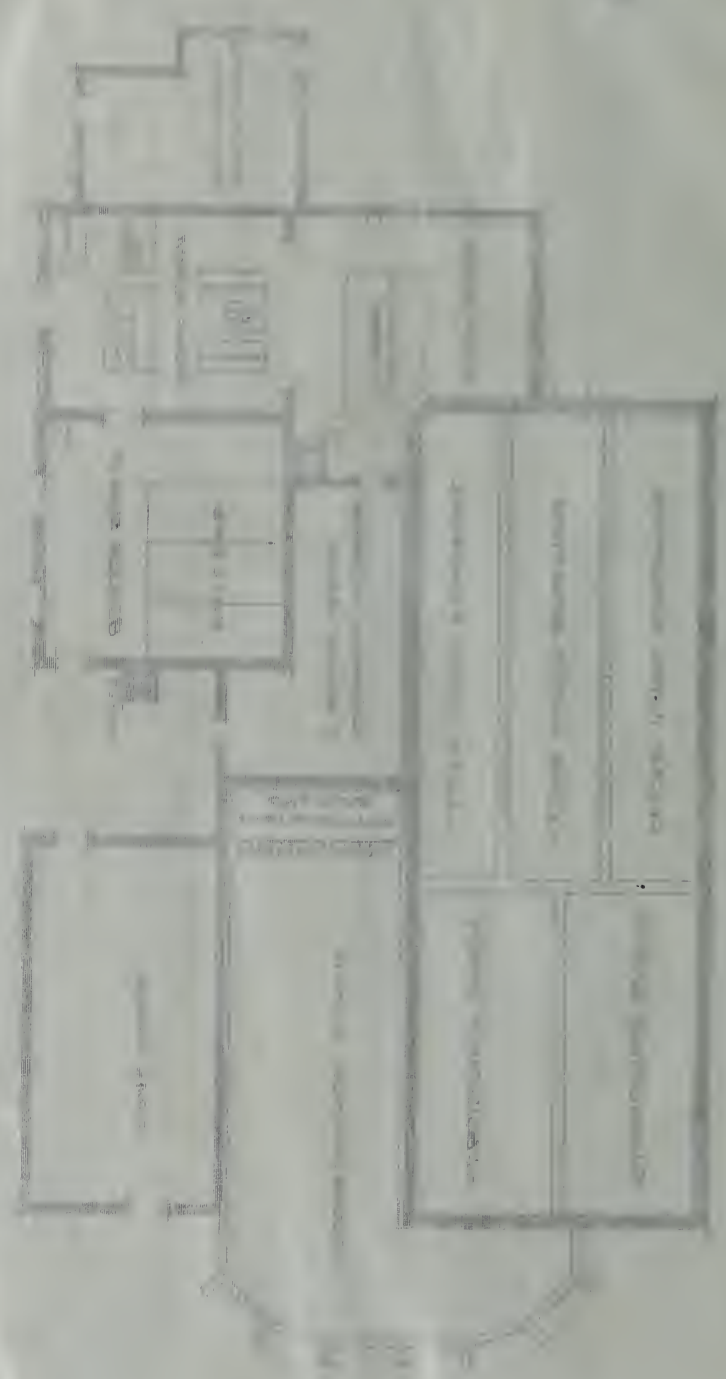
LIDLAW-DUNN-GORDON PUMPING ENGINE





—WATER WORKS PLANT—  
KANKAKEE, ILL.

PLAN OF THE HOUSE



# MECHANICAL ANALYSIS OF SAND

Test No. 1

Amount Analyzed = 400 grams

Sample from Filter Tank in the

Water Works Plant at Kankakee

Analyzed by J. B. Dabney

Date of collection March 27, 1910

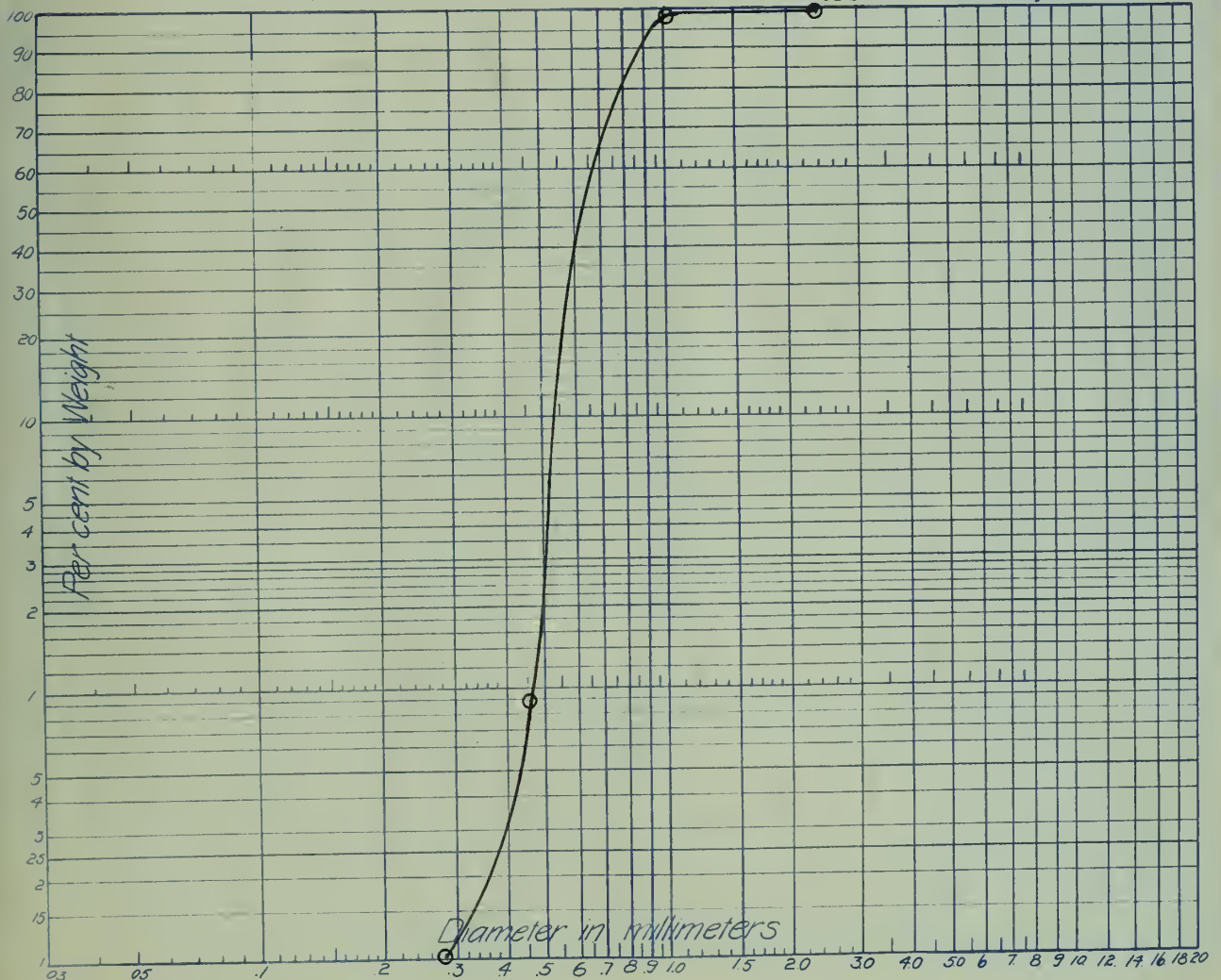
Date of analysis May 28, 1910

Remarks This sand had been  
in use several years.

Porosity 35 %

Sieve No	Separation Size mm.	Amount	Passing
		Grams	Per cent
10	2.35	400.0	100.0
20	1.033	377.2	99.5
50	0.480	4.2	1.0
74	0.27	0.4	0.1
100		0.1	0.03

Effective Size = 60 mm. Uniformity Coeff. = 1.23







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